Investigation into industrial generator maintenance culture in agro-based industries in Ibadan, South-West Nigeria

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Abstract: An investigation into the maintenance culture of industrial generators in the agro-based industries in Ibadan, South-West Nigeria has been carried out. The instrument used for this survey includes: interview, market survey direct observation and questionnaires. The study investigated the status of agro based industries with reference to electrical energy carrying capacity, level of compliance with service schedule, response time to failure and repair as well as cost implications in maintenance of such installations. Investigation revealed that over 75% of the agro-based industries in the South-West town of Ibadan are predominantly medium scale in status with a carrying capacity of less than 550KVA electricity generating equipment. There is high level compliance (92.5%) in keeping of daily maintenance record, negligence on long time fuel keeping (up to 5 weeks at times), a greater degree of negligence in mean time to repairs (MTTR) on malfunctioned components and poor response time to servicing the generator at the recommended hours of use. Therefore, the industries should greatly improve on their attitude to wake-up calls on equipment servicing if recurrent failure and excessive spending on generator is to be kept low. The continuous use of generator with malfunctioned part should be stopped. A stop and check approach is recommended immediately when abnormality is noticed in operation; there should be immediate stoppage, confirmation and correction of the fault just developed.

Keywords: Maintenance, malfunctioning, generator, capacity, reliability

1　Introduction

Nothing works well without electricity both in the business, industrial and domestic world. Therefore, power supply is crucial in every sector whether it is private or public. The variety of sources at which power is being generated is limited among the long chain of power supply options due to poor management, high cost, among other factors. Irregular power supply has been a general problem in the country these days and has reached a critical point as many Nigerians cry in different proportions about the setback which interrupted power supply has brought to them (Hakeem, 2006).

Nigerians have been suffering from a more severe epileptic power supply from the Power Holding Company of Nigeria (PHCN). This problem is a result of the nation's inability to produce enough electricity for distribution when demand is in the region of 6,000 megawatts per day and production is as low as 2,000 megawatts (Adegbulugbe and Akinbami, 1995). It has been revealed that over 30% loss in electricity power generation is adduced to vandalization of gas pipelines that supplies gas to Egbin and Afan thermal stations (Gary, 2004).These problems have led to alternative power generation found in generators of different capacities at various levels of production and consumer economy. One of such sectors that depend solely on generators for operation is the industrial sector, which depends on diesel fuel industrial generators to produce power for operation (Uwakwe, 2006).

Different models, capacity and manufacturers have been identified in Nigeria production sector. According to a field survey of industrial generator supply and distribution in South West Nigeria, 48.15% of the generators supplied were Perkins, Cummins and Caterpillar were responsible for 18.52% and 11.11% respectively (George, 1988).

The rate at which industrial generators are used in Nigeria calls for adequate maintenance, a culture rarely found in Nigeria production system. However, any establishment engaged in production and distribution of services must be able to keep production in full capacity by ensuring uninterrupted power supply offered by generators and well tailored maintenance programme (Robert, 2002; Hans, 2000)). Therefore, the objective of this paper is to investigate the maintenance culture of the industrial generators in some agro-based engineering servicing industries in the South western of Ibadan and their service response time.

2   Material and methods

A survey of five engineering servicing companies, operating industrial generators namely; Mass Engineering services, ODU'A Investment Engineering Services, Raymond Engineering Services, Caslat Engineering and God will Engineering company was carried out. The approach to this study includes administration of questionnaires, interviews and direct field investigation. Direct field interviews were conducted for technical staff operating industrial generators in order to validate responses documented in the questionnaires. Descriptive statistical tool was used to analyze the results. Parameters tested with corresponding adherence levels include; adherence to maintenance record keeping, length of time tolerating a malfunctioning part, extra hour of use before servicing among others. The respondents comprise of operators, artisanal mechanics or technicians operating industrial generators. To validate the responses descriptive statistical tool was used to analyze the results.

The following time related functions (Bello, 2012) were used in evaluating maintenance and repairs:

1. Mean time to repair (MTTR): It includes both the time elapsing before it is realized that there has been a failure(which will be very short for self-revealing faults) and the time for maintenance personnel to be deployed and achieve their repair mission. Good machine design can reduce MTTR and it is also influenced by maintenance procedure.

2. Mean time to failure (MTTF): This is the time elapsed for repairs to be done after the failure will occur. Good design can increase MTTF.

3. Mean time between failures (MTBF): This is the measure of the recurrence of failure in a system. It is a system mean time between two successive failures and also a factor of MTTF and MTTR i.e.

$$\text{MTBF} = \text{MTTF} + \text{MTTR} \qquad (1)$$

4. Reliability (r): Reliability is defined as the probability of survival of any system or machine component(s) throughout the time the machine is in operation.

$$R(t) = \exp(-\lambda t) \qquad (2)$$

Where

λ = Constant failure rate in unit of per second (1/sec) i.e. Failure/ time

5. Availability: The concept of availability is the fraction of time for which a machine or component(s) can perform its desired/designed functions.

$$\text{Availability} = \frac{\text{MTTF}}{\text{MTTF} + \text{MTTR}} = \frac{\text{MTTF}}{\text{MTBF}} \qquad (3)$$

3   Results and discussion

3.1 Literacy level of respondents

Educational status of the respondents indicated that 67% of them had post secondary level education which is an indication of tendency of high literacy level among the respondents.

3.2 Industrial size distribution in Ibadan, South-West Nigeria

Survey result shows that majority of the industries (75%) operated at the medium scale levels, judging from the statistics of the size of industrial generator of in use

(51KVA and 450KVA, which is the limits of the range of generator capacity under consideration). Among the small scale industries (20%), a larger percentage (>80% of this population generates and consumes between 3 to 5KVa of electricity. The remaining 5% represents large scale agro-based industries which are predominantly multinational confectionaries and agro-based processing industries

3.3 Generator capacity and fuel consumption characteristics

A total of 27 power generating equipment was investigated and classified based on capacities and distribution range according to individual power rating (Figure 1).The load requirements by these companies were distributed between the limits of the rated capacities of the generators under consideration in this study. A larger percentage (33%) of the generators sampled were classified in the small capacity range of 50-150KVA, 34% in the medium capacity range (151-350 KVA) and a total of 33% in the heavy duty capacity range (351 KVA and above). Based on this information about the industries under survey, greater percentage (74.07%) of the industries operates within the medium size industry
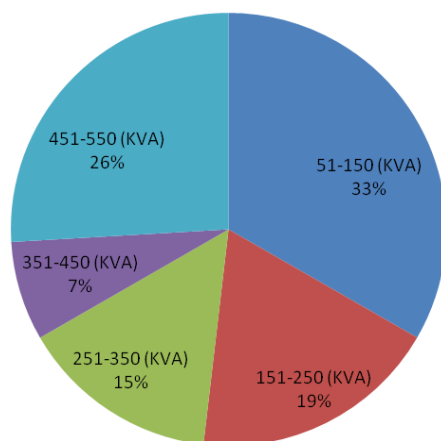

Figure 1 Percentage distribution of generator capacity

The rate of fuel consumption per hour ranges between 11 liters minimum and 130 liters maximum for the high capacity engines. The tank capacity varies from 101 to above 1100 liters for the range under investigation. Majority of the engines (74%) are straight engine

arrangement and 25% of them are v-engine arrangements. The status of the engine at purchase indicated that 67% of the generators were purchased brand new while the rest are either second hand or fairly used and the average weekly hours of use ranges between below eight hours and above 75 hours not exceeding 100 hours.

3.4 Compliance with maintenance recordkeeping

There is high level compliance (92.59%) with daily record keeping of maintenance activities among the respondents according to the specification on daily record keeping recommended and the ideal practice that is required for proper maintenance of industrial generators, 3.85% keeps weekly and fortnightly respectively while none keeping monthly records. According to the specification on record keeping, daily record keeping is the recommended and the ideal practice that is required for proper maintenance of industrial generators. This information helps an operator/mechanic to monitor the performance characteristics of the generator and provide the appropriate repair and maintenance measure required at failure.

3.5 Tolerance to malfunction (Mean time to failure, MTTF)

There exists a poor management response to general precautionary measure of putting generator to use when there is an established component malfunction. This is evident as indicated in Table 1: 51.85% of the respondents has poor tolerance coping with a malfunction per day, 22.22% could tolerated it for one week, 7.41% of the respondents alleged using their generator with a malfunctioned part for two weeks before effecting a repair. Only 7.68% could not tolerate using a malfunctioned component in emergency situation without repairs. By implication, 90.29% of the management was complaisant to component failure while 9.74% treated cases of malfunctioned component promptly. This result has obviously increase respondent tolerance to component malfunction and reduced mean time to failure.

Table 1 Tolerance in use after established component malfunction

Time	Distribution	Distribution/%
One day	14	51.85
One week	6	22.22
Two Weeks	2	7.14
Over Two weeks	3	11.11
None	2	7.68
Total	**27**	**100**

3.6 Regular maintenance schedule (Mean time to repair (MTTR) on assembly)

All of the respondents exceed the scheduled hours of maintenance by running the generators 5-20 hours beyond the recommended time lapse (Table 2). There is a total departure from the regular routine maintenance of industrial generators recommended for servicing every 200 hour or 250 hours of use depending on the manufacturer's specification (Perkins manual, 2003). For instance, to ensure good operational efficiency, the filters and oil must be changed at the specified time. Also the necessary parts of the generator must be checked at the appropriate time; however, failure to carry out such maintenance on schedule may not cause an immediate problem, but could affect machine performance as well as prolong mean time to tracing fault and repairs in case of damaging effect.

Table 2 Percentage distribution of average hours of generator use before servicing

Time/h	Distribution	Distribution/%
1-5	8	29.63
6-10	6	22.22
11-15	1	3.70
16-20	6	22.22
Above 20	6	22.22
Not done	-	-
Total	**27**	**100**

3.7 Reliability (r)

The reliability of the generators was evaluated as a function of time and the exponent of the constant failure rate in unit time per second. Respondents report on frequent breakdown in component is an indication of poor reliability of products components with a slight departure on few occasions (less than 21%) when machine breakdown in mid operation due to component failure with resultant effect of reduction in the output and service life of the generator. This bias from the standards is the consequence of the poor managerial attitude (slow response, ignored response and complacency) towards maintenance requirement (Figure 2).
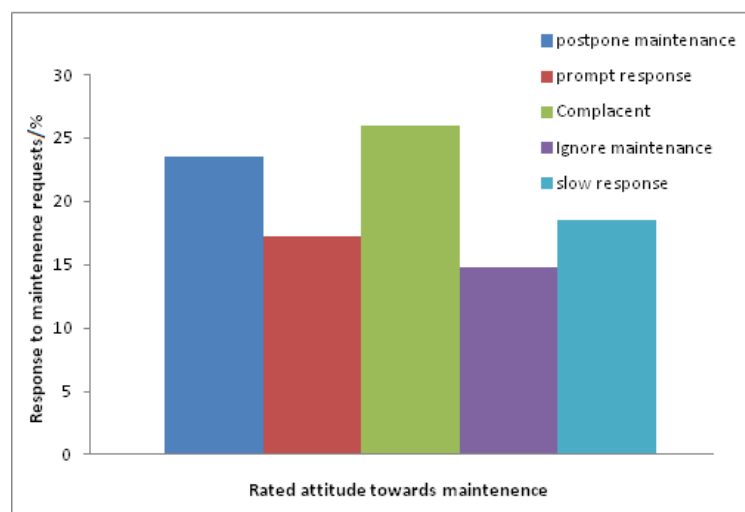

Figure 2 Managerial attitude towards maintenance requirement

3.8　Fuel run-out and storage

A fair response of survey outcome (18.52%) indicated that generator do ran out of fuel once or twice during the course of their operation. This showed some level of commitment to good work practice and procedure by the operators, but such occurrence can be totally eradicated by being more proactive; a major consequence of fuel run-out is the generator sucking air resulting into injector and mechanical failure in the engine system. quite reasonable number of the respondents stores fuel for a period ranging from 1 week to 5 weeks. From reports, 37.04% of the respondents stores fuel in tanks for a period not exceeding one week, 25.93% for 2-3 weeks, and 22.22% for up to 4 to5weeks. It is known that fuel quality has a resultant effect on the engine performance and the length of storage affects the quality of diesel fuel as well. Storage time of no more than one week has been considered ideal for fuel storage. However, the fuel gradually deteriorates both in quality and quantity if it is stored beyond the time limit of one week.

3.9　Costs of servicing and maintenance

The average servicing cost and variations between the highest and the lowest costs of service collected from five major engineering companies studied in this survey for servicing Perkins engine generators at selected capacities of 40KVA, 100KVA, 200KVA and 500KVA is shown in Table 1. It is evident that servicing costs increases marginally as the capacity of the engine increases. Differences (variations) in service charges among individual company are dependent on efficient service delivery, the taste of the client, location and the manufacturer's trademark. The bills presented in the table was the minimum possible price based on available data supplied by the individual company at the time of conducting this survey; more varied prices are still possible, based on choice and some of the factors mentioned above.
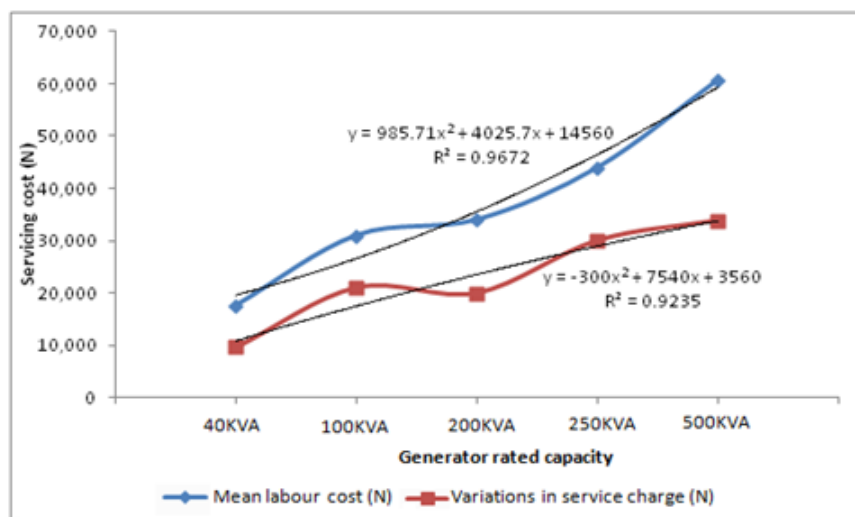

Figure 3 Average servicing costs and cost variations for servicing Perkins generator

The mean labour charges by artisanal personnel for servicing similar industrial generators at selected capacities are shown in Figure 4. The result shows same trend; that the higher the capacity of the generators the higher the labour charges for maintenance. The factors considered as influencing these variations also acts on charge for labour which in turn affects the service delivery as a whole. However, Figure 4 gives a user idea of what should be the average charge for workmanship at specified capacity and also guides decision making on preference of who purchase the spare parts and other consumable items for servicing.
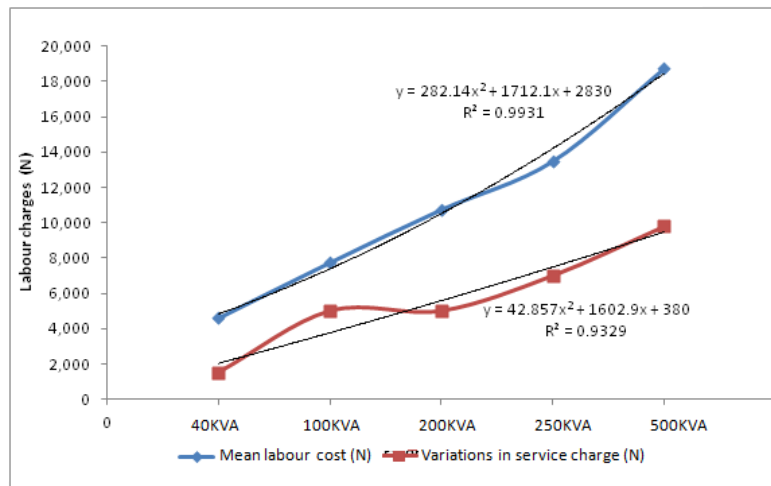
Figure 4 Charges for individual labour for servicing Perkins generator

4   Conclusion and recommendations

Among the agro-based industries in the South-West town of Ibadan, 75% are predominantly medium scale industries with 33% having electricity carrying capacities of between 50-150KVA, 34% in the medium capacity range (151-450 KVA) and a total of 5% in the heavy duty capacity range (451 KVA and above). Maintenance culture of these range of generators showed some significant levels of compliance with standard procedure for generator maintenance standards. Level of compliance with daily maintenance record keeping of 92.5% was observed for daily maintenance, with some level of complacency for weekly (3.85%) and total neglect for monthly maintenance. However, a greater degree of negligence was exhibited in tolerance to repairs on malfunctioned components, and poor response time to generator service schedule at the recommended hours of use. This is an indication of high mean time to failure and frequent component breakdown.

It is recommended that the industries should be more proactive in responding to scheduled maintenance programme and greatly improve their attitude to wake-up calls to servicing duly if recurrent failure and excessive spending on the equipment is to be curtailed. The continuous use of faulty generator with malfunctioned parts should be discouraged while a stop and check approach is observed once an abnormality is noticed as the generator runs; there should be immediate stoppage, confirmation and correction of such fault. However, if

this is tolerated smaller faults will lead to bigger ones causing excessive breakdown resulting into greater economic losses.

References

Adegbulugbe, A.O., and J.F.Akinbami.1995. Urban Household Energy Use Pattern in Nigeria. National Resources Forum, Elsevier Science Ltd., Great Britain, 19(2) Pp 125-133.

Bello R. S. 2012.   Farm Tractor Systems: Operations and Maintenance. *Pub by Createspace   7290 B. Investment Drive   Charl US.*ISBN-13:   978-148-102-292-7 URL:https://www.createspace.com/3996235 Sept 2012.

Dennis, A. S. 2002. Plant Engineer's Reference Book Second Edition Published by Reed Educational and Professional Ltd., Pp 22/3 – 25/5.

Gary, R. 2004. Technology Alternatives. A publication of America society of mechanical engineers. *ASME*, 126(4): 27.

George, H.C. 1988. Industrial and Marine Fuels Reference Books. First Publication. Published by Butterworth and Co. Ltd. Pp 1/26 – 4/13.

Hakeem, S. 2006.   Power and Poverty Alleviation. Published by the Nigeria Tribune May 30, Pp 8-9.

Hans, L. 2000. Measuring Maintenance Performance - in search for a maintenance productivity. *Index International of Production Economics*, 63:47-58.

Perkins Manual.   2003. Generator Operation and Maintenance manual. Published by John Holt Engineering Company. Pp 10-20.

Robert, C. R. 2002.   Standard Handbook of plant Engineering. Third Edition Published   by Mc Graw – Hill Pp 6.59 – 6.143

William, K.T. 1983.   Diesel Fundamental services and repair Published by the Good hewart-willcox Company, Inc Pp8-260.

Uwakwe, A. 2006. The National Power Supply. Published by daily Independent Vol 3 No 1013 Thursday, July 20,Pp 5A.